Montana Dam Safety Outlet

No. 5 Dam Safety Program, Montana Department of Natural Resources and Conservation June 1999

## Spillway Committee Makes Recommendations to Montana Department of Natural Resources and Conservation

Spillways are an important element of any dam. Water will overtop the dam during a flood, if the spillway is not adequately sized. For earth-filled dams, overtopping most often leads to complete dam failure. This failure can result in loss of life as well as significant property damage. Overtopping of concrete dams can also lead to failure, but not unless the level of water over the dam is significantly higher.

Under former Montana rules, the amount of water that existing spillways needed to convey was treated essentially the same, regardless of the population downstream of the dam. Some spillways in remote areas were required to pass enormous floods at great cost to the owners.

The Montana Spillway Standards Committee has made its final recommendations on spillway size to the Montana Department of Natural Resources and Conservation (DNRC). The committee, formed in the spring of 1997, has been advising DNRC in drafting new rules for spillways. The committee is made up of dam owners, residents who live downstream of dams, consulting engineers, and government employees.

For complete safety, the spillway would need to convey the maximum flood that could ever occur. However, this would be cost-prohibitive, just as making automobiles that are completely safe is cost-prohibitive. Therefore, the size of spillway required for each dam will depend on the population level below the dam. Owners of dams with large populations below will be held to a more stringent criterion for spillway size than owners of those dams with small populations below.

One of the tasks the committee faced was determining an appropriate risk level. The risk that the committee decided is acceptable is that there be a 1-in-1,000 chance that a life would be lost in any given year due to spillway failure. For example, if 5 lives would be lost due to spillway failure, the spillway would need to convey the 1-in-5,000 flood or the 5,000-year flood. To put this in perspective, most floodplain regulations are for the 100-year flood.

Because of potential population growth, dam owners who are building new spillways will be encouraged to build spillways that exceed the minimum requirements. In this way, they can protect themselves from being out of compliance shortly after they complete their new spillways.

The committee also recognized that it would be unreasonable to expect all existing dams with spillways that do not meet the standard to be brought into compliance immediately. Therefore, DNRC will prioritize the most hazardous dams. Owners of dams that do not meet the standard but are not imminently hazardous will have more time to bring their dams into compliance. DNRC will work with the owners by considering such factors as grant cycles and construction seasons to bring the dams into compliance with state dam safety standards.

Presented in this newsletter is an excellent article by Jason Thom, P.E. (a member of the Montana Spillway Standards Committee) that reviews the work completed by the committee. For more information regarding the proposed spillway standards, contact Terry Voeller at 444-6664.

# Montana Dam Safety Spillway Standards Modifications

*By Jason H. Thom, P.E.*

For the past two years, a broad-based committee has been working to develop new spillway design standards for high hazard dams in Montana. The committee consists of various dam owners, affected downstream residents, DNRC engineers, consulting engineers, and federal government experts. The committee has developed proposed standards regarding minimum allowable spillway capacity. The proposed rules will undergo public meetings, formal public notice, and comment process necessary to modify the Administrative Rules of Montana.

This article will discuss three spillway standards: (1) the original standards, (2) the interim standards, and (3) the proposed standards. The original standards regulate spillway capacity as a percentage of the probable maximum flood (PMF) based on the size of the dam and reservoir. There is very little consideration of the level of risk associated with downstream development. The interim standards were established in 1995 to allow time for analysis and development of risk-based (rather than PMF-based) criteria. The interim standards allow a minimum spillway capacity of the 500-year flood for all dams. The interim standards were adopted to avoid forcing dam owners to complete expensive repairs to meet the PMF standard, while a more logical, risk-based standard was developed. The proposed standards include a risk-based criterion with the spillway capacity being dependent on the loss of life anticipated from a dam failure.

A central concept of the proposed standards is the computation of the anticipated loss of life (LOL) from failure of the dam. Statistical analyses have been completed on past flood catastrophes to relate LOL to the population at risk (PAR), warning time, and force of the flood wave (high or low impact). A large dam with a long travel time to the PAR and a low force wave at the population location could have a large PAR and a relatively low LOL due to people being able to escape the flood wave. A small dam could have a smaller PAR, but no warning time and a high force wave that would result in a high LOL.

The committee selected a target maximum level of risk of 1 LOL in 1,000 years. That is to say, if the LOL is 5, the design flood should be the 5,000-year event; if the LOL is 1, the design flood should be the 1,000-year event. The 1-in-1,000 criterion was selected based on a comparison of risk levels used by other agencies and design of engineered structures throughout society in general.

DNRC recently funded jointly two studies by Chuck Parrett of the U.S. Geological Survey (USGS) to develop methods for determining the frequency of extreme precipitation events and for distributing the precipitation intensities. These studies are now complete and provide methods to compute floods for a risk-based analysis up to the 5,000-year event. The committee determined that, for dams with LOL greater than 5, the design precipitation depth will be interpolated between the 5,000-year storm at 5 LOL and the probable maximum precipitation (PMP) at 1,000 LOL. This maintains the 1-in-1,000 risk level, if it is assumed that PMP is approximately a 1,000,000-year event (a large but necessary assumption).

For purposes of illustrating the spillway standards, three hypothetical dams will be reviewed. To keep them straight, let's say that the owners are Art, Bob, and Kevin. Art owns a very small recreational dam located in a scenic mountain canyon. There is a large subdivision located immediately below Art's dam. Even though the dam is only thirty feet high, failure of the dam would likely result in a high LOL. Bob, on the other hand, owns a slightly larger dam (forty feet high) that he uses to irrigate his farm. This dam is located in a relatively remote area, with a failure impacting only one house that is seasonally occupied and located five miles downstream. Kevin owns a large reservoir (20,000 acre-feet) and dam (70 feet high) in eastern Montana with five houses at risk between 3 and 20 miles downstream. The valley is wide in the area of the houses, and the flood wave would be relatively shallow and slow moving.

Under the original standards, Art's dam must have a spillway capacity of 10 percent of the PMF or the 100-year flood, whichever is greater. The interim standards require capacity to pass the 500-year flood, which the dam currently meets. PAR is 250 people, with the estimated LOL due to failure of 55 people. The proposed standards would require an interpolation between the 5000-year storm and the PMP to approximate the 55,000-year event. The LOL risk without rehabilitation would be 55 per 500 years or 1 LOL per 9 1 years. This is a very

*(Continued on Page 3)*

## Spillway Standards

*(Continued from Page 2)*

high LOL risk. This dam would be ranked as a high priority to be rehabilitated under the proposed standards, as the LOL risk is much more likely than the selected target of 1 per 1,000 years. Immediate action should be instituted at this dam.

Bob's dam must pass a flood of 30 percent of the PMF based on the original standards. PAR is 3, and the estimated LOL is 0.1. *(You may ask, "How can an engineer come up with a partial fatality?" This represents a statistical value that, if there were 10 failures under these conditions, one LOL would be anticipated. In other words, if the dam fails the odds are 1 in 10 that there would be a fatality.)* The interim standards require a 500-year capacity, and the proposed regulations also require a 500-year capacity as the minimum for a high hazard dam. Bob's present spillway can handle the 600-year flood, so no modifications would be required. The LOL risk would be 0.1 LOL per 600 years or 1 LOL per 6,000 years, which is one-sixth of the risk of the target of 1 in 1,000. It should be noted that additional development could occur below Bob's dam without a need to upgrade the spillway until the anticipated LOL is 0.6.

Kevin's dam currently has a spillway capacity to pass the 400-year flood (15,000 cfs). PAR is 15 people, with anticipated LOL of 0.7. The original standards would require 75 percent of the PMF (120,000 cfs); the interim standards the 500-year flood (17,000 cfs) and the proposed standards the 700-year flood (21,000 cfs). This dam would, therefore, have to be modified to increase the spillway capacity. Under the original standards, the design flood would have been many times greater than the requirement under the new standards. The present risk would be 0.7 LOL per 400 years or 1 LOL in 571 years.

In comparing Kevin's dam to Art's dam, it becomes apparent that the risk to downstream residents is much higher at Art's dam even though the dam is much smaller. The proposed standards are intended to help identify those situations likely to pose the highest risk of loss of life. They also provide a more equitable basis for determining spillway capacity. Generally, the proposed standards will result in smaller spillway requirements while maintaining reasonable risk levels. However, there may be cases such as Art's where the new standards will require much more spillway capacity for a dam that was considered "safe" under the original and interim standards.

Public presentation of the proposed rules will take place this summer in Billings, Big Sky, Missoula, Havre, Helena, Kalispell, and White Sulphur Springs.

*Jason H. Thom, P.E., is MSE-HKM's Senior Project Manager for Water Resources. He provides technical and management oversight of dam rehabilitation projects from planning through construction and start-up. Mr. Thom has been responsible for oversight of construction on more than a dozen high hazard dam rehabilitation projects. He has fifteen years of experience at MSE-HKM, preceded by three years of experience with the U.S. Bureau of Reclamation. Mr. Thom has a Civil Engineering degree from Montana State University and is licensed in Montana and Colorado. He is an active member of the advisory committee working with DNRC to revise the Montana regulations for high hazard dam spillway requirements.*♦

## National Dam Safety Act Funding Used to Initiate Owner Awareness Program

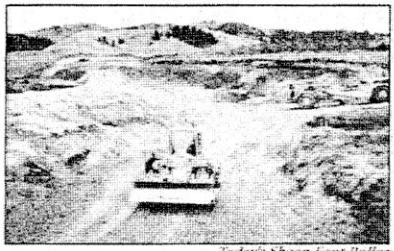
Each state in the nation was provided funding under the National Dam Safety Act to improve its Dam Safety Program. The State of Montana decided to utilize the funding to initiate a statewide owner outreach program, with particular attention to dam maintenance.

The number one cause of dam failures is lack of adequate maintenance. The best way to identify maintenance needs is for the owner to become familiar with the dam and do regular site inspections. DNRC engineers will be working closely with owners throughout the state to assist them in conducting regular site inspections, as well as identifying maintenance needs on their dams. The engineers will also be assisting owners in reviewing their operation and maintenance plans to ensure that they are a useful tool.

Another aspect of this program will involve Disaster and Emergency Services (DES) coordinators. DNRC engineers will be contacting each county DES coordinator to discuss and review emergency action plans for high hazard dams in that county.

It is anticipated that this program will take two years to complete. If you need more information, please contact Michele Lemieux, Dam Safety Program Manager, at 444-6613.♦

## Advances in Dam Construction Technology



*Today's Sheep Foot Roller*

No kidding! Livestock were commonly used to compact earth embankments! Upper Glaston Lake Dam, in Sweetgrass county was built using sheep.

*Sheep Foot Roller used in early 1900's*

After placing a foot of fill, sheep were fenced on the dam overnight. In the morning, the sheep were then removed and another of foot of fill was placed.♦

## Good Turnout for Flood Hydrology Seminar

This year's Dam Safety Seminar was held in Butte, Montana, on March 30-31. The emphasis of the seminar was on flood hydrology in Montana with particular attention to the latest techniques developed by the U.S. Geological Survey (USGS). The instructors of the course were Chuck Parrett of USGS, Gary Fischer of Maxim Technologies, and Terry Voeller of DNRC. The course provided a good overview of hydrology, with discussions on everything from unit hydrograph development to paleohydrology. More than 75 people attended. It is anticipated that the annual Dam Safety Seminar next year will be on seismic design and evaluation of dams. West Yellowstone comes to mind as a prime seminar location! It will likely be in March or early April of the year 2000.♦

*Persons with disabilities who need an alternative, accessible format of this document should contact: DNRC, 48 North Last Chance Gulch, P.O. Box 201601, Helena, MT 59620 -- Phone: 444-6603/Fax: 406-444-0533/TDD: 406-444-6873*

*375 copies of this document were published at an estimated cost of 16¢ per copy. The total cost of $172 includes $60 for printing and $112 for distribution.*

**Montana Department of Natural Resources & Conservation**
**Dam Safety Program**
P.O. Box 201601
48 North Last Chance Gulch
Helena, MT 59620-1601

*ADDRESS CORRECTION REQUESTED*